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ON THE EPIZOOTOLOGY OF ELAPHOSTRONGYLOSIS IN "PANTY" DEER*

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E.I. PRYADKO, S.N. VYSOKOV and V.S.FROLOV

At present several neurotropic species of parasitic nematodes are known. They belong to two large suborders: Filariata and Strongylata.

Of the filariates, Setaria cervi Maplestone, 1931 is known from Japan, Korea and Ceylon as a parasite of the spinal cord of horses, sheep and goats (Whitlock, 1959; Itagaki, 1959); S. altaica Rajewskaya, 1928 occurs in Altai and is parasitic on the brain of "panty" deer (Lyubimov, 1950).

Of the strongylates, Elaphostrongylus panticola Lubimov, 1945, a helminth infesting the brain and spinal cord of maral and spotted deer, is known from Altai and the Maritime Territory (Lyubimov, 1950, 1959). Related species in North America parasitize the spinal cord of sheep and cerebral tissues of the American elk (Whitlock, 1959), and in Scotland infest the thoracic cavity tissues and back muscles of red deer (Skrjabin, Shikhobalova, Shul'ts, Popova, Boev, Delyamure, 1952; Boev, 1957).

Setaria cervi, Setaria altaica and Elaphostrongylus panticola are extremely pathogenic helminths. All of them cause diseases of the central nervous system: the first, in sheep, goats and horses; the second and third, in marals and spotted deer.

Particularly in Altai, great damage is caused to maral-breeding farming by elaphostrongylosis. According to M.P. Lyubimov (1959), infection of marals by elaphostrongyls on Katon-Karagai and Verkh-Katunskii maral-breeding sovkhozes reached 61.2 – 75% in recent years. Such widespread invasion in some years causes enzootic outbreaks resulting in heavy mortality of marals. In 1940, on Verkh-Katunskii sovkhoz scores of marals perished of elaphostrongylosis (Lyubimov, 1950). Local residents reported an even greater enzootic outbreak at the same place in the mid-1930s.

Immense damage to the farm was inflicted by an enzootic elaphostrongylosis outbreak in the winter of 1961/62. During December, January and February 146 animals died of brain helminths, amounting to 63.6% of the total maral mortality on the farm for that period. This caused the farm

* [Russian "panty" refers to the soft core of young antlers of certain species of European and Oriental deer. Pantocrine, extracted from the "panty," is extensively used in Russia and the Far East as a medicament and tonic

colossal losses. Each maral yields annually on this farm an average net profit of 232 rubles 29 kopeks. Most maral stags produce antlers [panty] for a period of 10 years. Consequently, every stag that perished represented a loss of 2,322 rubles. If half the marals which died or had to be destroyed were males (73 animals) and the other half were does (worth 41 rubles on the books), the financial loss incurred by the last enzootic outbreak, was 169,506 rubles (new prices). True, the slaughter of marals did produce some profit in meat (50 rubles per centner), hides (3 rubles) and the secondary export produce: tails (5 rubles apiece), male genitals (7 rubles) and tendons of fore and hind legs (5 rubles per kg). But this profit is canceled out by the loss of the capital value of the animals.

One of the causes of high mortality of animals which contracted elaphostrongylosis was, in our opinion, the presence of multiple infections. Along with the elaphostrongyls, setarid worms were often found under the dura mater in dissections of dead marals (Figure 1). Out of 17 marals dissected in the winter, cerebral setarid worms were detected in 7 cases (23.3 %). Although no more than one to three setarid worms were found in a single animal, their harmfulness due to their large size is beyond doubt.

FIGURE 1. Elaphostrongyls and setarid worms (in center) on pia mater of maral's brain

The resistance of marals was considerably lowered also by other helminths, such as *Dictyocaulus* (Figure 2) and *Trichuris*. In a few cases infection by these two worms was so massive (hundreds of individuals), it was difficult to determine which of the helminths caused the animal's death.

Elaphostrongyls in the Altai were first described by M.P. Lyubimov (1945), who subsequently worked out the parasite's life cycle, propagation, pathology and the clinical picture of the disease, as well as seasonal and age-dependent dynamics, prophylaxis and therapeutics. However, in spite of this considerable work, numerous questions relating both to the biology of the parasite and the therapeutics of the disease remained uninvestigated. Our research is a continuation of Lyubimov's studies.

FIGURE 2. Mass of Dictyocaulus in maral's bronchus

We carried out the study of elaphostrongylosis epizootology of spotted deer and marals on the Katon-Karagai deer-breeding sovkhoz and Verkh-Katunskii maral-breeding sovkhoz from May 1961 to February 1962. During th period 18 marals and 8 spotted deer were completely dissected for helminths, and 12 marals and 1 spotted deer were partially dissected. Blood tests for filaria and elaphostrongyl larvae were performed on 963 living animals and 893 samples of feces were examined for elaphostrongyl larvae (metho of Berman and Vaida). The examinations were made at different seasons of the year; samples for tests were taken from animals aged from two months to thirteen years.

The damage caused by elaphostrongylosis was assessed from the veterinary records of the Verkh-Katunskii sovkhoz for the years 1961—196

Our investigations showed that the rate of elaphostrongyl infection of deer bred on the sovkhozes investigated is very high. According to

coprological examinations, the incidence of infestation of marals on Verkh-Katunskii sovkhoz is 82.3% and on the Katon-Karagai sovkhoz 60.7%.

The prevalence of elaphostrongyls is also indicated by the materials obtained from postmortem examinations. Out of 30 adult marals dissected, mature forms of elaphostrongyls were detected in 16 (15 of them on the Verkh-Katunskii sovkhoz). As a rule, the intensity of invasion exceeded 100 parasites per animal.

The dissections for helminths were instrumental in establishing the considerable extent of infection in spotted deer as well (52.2%). However, mature forms of elaphostrongyls were not found in spotted deer. Blood examinations for elaphostrongyl larvae in marals and spotted deer were negative.

The age dynamics of elaphostrongyl infection, as determined by coprological examinations, are as follows: young marals aged 4 to 6 months had an infestation incidence of 4.5%; 6 to 8 months, 54.6%; $1\frac{1}{2}$-year-old calves (females and males) 95.2 to 100%; adult females 71%; adult stags 85.6%.

No elaphostrongyl larvae were detected in feces of young spotted deer aged 2 to 3 months; 4 to 6 months, 10%; 14 to 15-month-old deer, 60%; adult does, 61.7%; adult stags, 62%.

The absolute numbers of larvae in the samples are very high in $1\frac{1}{2}$-year-old animals (hundreds are seen within the field at mag. 3.7—7×). In old animals larvae are counted by the scores; in maral stags, only solitary larvae. The index of infestation for both adult and young spotted deer is practically the same (in the microscope field, usual numbers of larvae range from 10 to 30).

According to the coprological examinations, age-group differences in incidence of elaphostrongyl infection are observed only in marals; the highest rate of infection was recorded in young marals.

Other observations confirm this conclusion. The last enzootic elaphostrongylosis outbreak on the Verkh-Katunskii sovkhoz was confined exclusively to young marals of both sexes.* Dissections of $1\frac{1}{2}$-year-old animals revealed hundreds of sexually mature helminths (up to 386), whereas in marals of other age groups numbers of helminths never exceeded several score.

These results on age-group dynamics of elaphostrongylosis differ from the data of Lyubimov (1950). He concluded that calves in their first year are more susceptible to infection by helminths. Our facts show that young deer over a year old are most susceptible to infection.

This leads to the view that unequal degrees of infection in antler-trade deer of different ages depend not so much on the animals' age as upon factors of the surrounding external medium. Among these factors are the character of the pastures (dry, marsh-ridden, wind-fall litter), actual usable area (which determines whether the herd pastures under normal or crowded conditions), the density of the intermediate host population, the degree of infestation of the deer parks in preceding years, dung on pastures, etc.

The seasonal dynamics of elaphostrongyl infection are as follows. According to coprological examinations, the extent of invasion of both

* Prior to the enzootic outbreak, sporadic deaths of adult marals due to elaphostrongylosis had been recorded.

spotted deer and marals is practically unvarying in both the warm and cold seasons. For deer the incidence of infection is 54.6% in summer and 52.3% in winter, and for marals 70% in summer and 76.5% in winter. However, the numbers of larvae in fecal samples, especially of marals, are much higher in winter, reaching in isolated cases thousands of parasites in the microscopic field (in summer there are no more than several score).

The seasonal variability of elaphostrongylosis in marals is also apparent from death statistics. Thus during the entire pasturing period on Verkh-Katunskii sovkhoz only one animal died of elaphostrongylosis. In winter, on the other hand, about 150 marals died of this disease.

Our findings on the seasonal dynamics of elaphostrongylosis coincide with data of Lyubimov (1959), who characterized elaphostrongylosis as being markedly variable by season: rising in winter, dropping to a minimum in summer.

We ascribe the widespread incidence of elaphostrongylosis in winter not only to the parasite's biology, as does Lyubimov (1959), but to the factors connected with deer husbandry techniques as well. We consider that the winter mortalities due to elaphostrongylosis among young male and female marals are caused primarily by poor pasturing management. This age group was pastured on marshy tracts where mollusks abound; they entered the winter period in a poorly-nourished condition, and in the winter additional feeding with concentrates was not practiced.

It should be noted that a particularly virulent winter epidemic broke out among young marals that were pastured during the whole summer (crowded on marshy tracts, as mentioned above) in an isolated park on which marals had not been kept since 1940. In the past this particular area had been associated with morbid enzootic outbreaks of elaphostrongylosis.

The source of the infection may be one of two: either due to elaphostrongyl larvae persisting for a score of years in this park, or else due to reinfection and cross infection among the marals. The latter is more probable, considering that invasive larvae outside the intermediate host perish quickly (Lyubimov, 1959), and it is doubtful whether mollusks, elaphostrongyls' intermediate hosts, can survive for a score of years. The very crowded maintenance of marals on marshy pastures creates favorable conditions for helminth development and the ensuing mass reinfection of marals, possibly repeatedly.

As already stated, mature forms of elaphostrongyls were encountered only in marals. These parasites are located in most various tissues in the brain and spinal cord (under the dura mater, in the cerebral ventricles, within and under the pia mater and in the brain itself), in the eye, intercostal and lumbar muscles, and the peritoneum (Figures 3–7).

In a total of 97 dissections, sexually mature helminths were found under the dura mater in 16.5% of cases (6 to 200 elaphostrongyls), in the cerebral ventricles in 11.3% (1 to 19), in the pia mater in 13.4% (19 to 113), underneath the pia mater in 12.5% (4 to 43), the brain itself in 1% (1); in the spinal cord underneath the dura mater in 14.4% (3 to 35), under the pia mater in 13.4% (1 to 7); in eye tissues in 2.1% (1), in muscles in 3.1% (1 to 2), and on the peritoneum in 1% (1).

On dissection of marals stricken by elaphostrongylosis, their emaciation is evident, with marked atrophy of muscles and marked edema in the thoracic

FIGURE 3. Elaphostrongyls on the inner surface of the dura mater in the brain of a maral

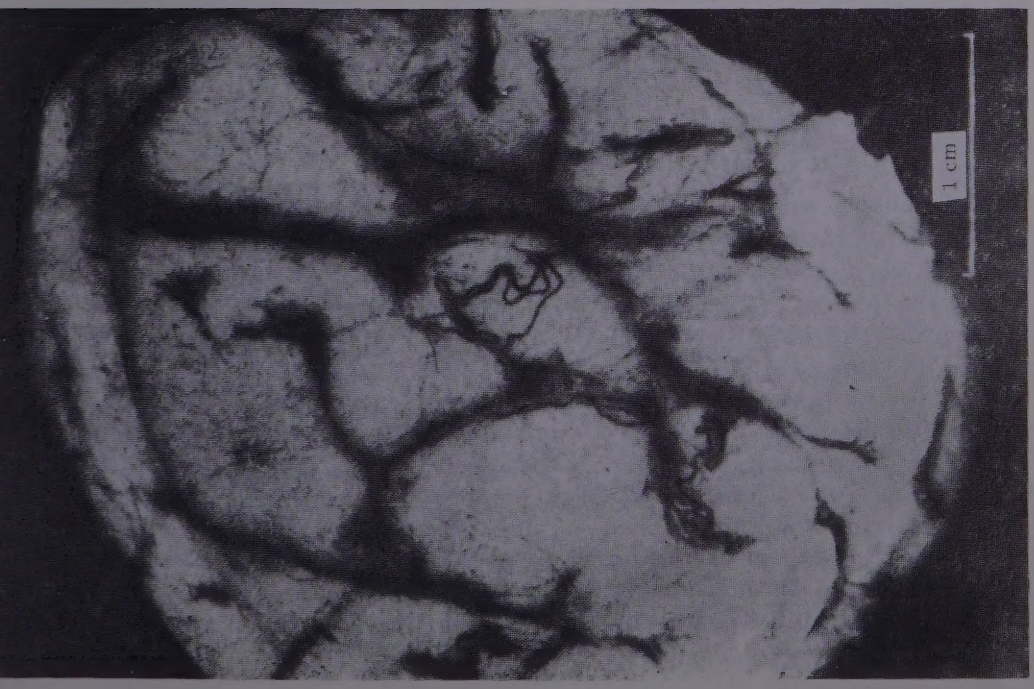

FIGURE 4. Elaphostrongyls imbedded under the pia mater in the brain of a maral

and abdominal cavities. The parenchymatous organs (liver, heart, kidneys) exhibit no pathological changes. The dura and pia mater are inflamed in places with swollen vessels; the brain cavity contains a considerable quantity of transparent exudate. Thin brownish nematodes, 3 to 4 cm long, are detected under the dura mater.

The helminths in the dura mater are not attached to the tissue and being highly motile, tend to enter into the cerebral convolutions after the damage to the dura mater becomes extensive. The helminths complet or partially immured in other membranes tend to remain in place.

The most pathogenic action of helminths is localized in the host's brain where their numbers exceed three hundred. The abundance of helminths in the brain produces various nervous symptoms in marals. (Figures 8, 9).

Sick animals lag behind the herd, standing with the head lowered for long periods. Sometimes, with the head thrown back, these animals aimlessly circle around the same spot or move straight forward, sideways, or backwards. On dropping to the ground they lie listlessly for a long time, then again rejoin the herd. Slight paralytic symptoms appear. The gait becomes uncertain, the animals moving with side forward, falling on their hind limbs. In spite of considerable weakness, sick animals often show fits of agressiveness: attacking a horse, a man, and rider on horseback (especially if these approach them closely). At a later stage, stricken marals hide from the herd, and after the onset of full paralysis, perish.

Among spotted deer, there were cases of lumbar paralysis (Figure 10). It is possible that this symptom is caused by elaphostrongyl parasitism; the location of the worms was not determined (larvae were observed in the feces).

It is known that phenothiazine, recommended for several types of strongylosis, including elaphostrongylosis (Lyubimov, 1953), has prophylactic properties. This preparation does not kill helminths, but reduces the egg production of the females and weakens the eggs and larvae However, immediate therapeutic effect can only be achieved if the parasite itself is killed.

For that purpose ditrazine-phosphate was tested. This substance is us remedially for onchocerciasis and pulmonary nematode diseases of domestic ruminants (Gnedina, 1953; Ozerskaya, 1957; Umov, 1957).

First, ditrazine-phosphate was tested for toxicity on newborn animals (weighing 120 to 130 kg) having no clinical manifestations of elaphostrongy losis. Doses of 0.05, 0.1, 0.15, 0.2 and 0.25 grams dry weight per kilogram animal weight were administered subcutaneously in a fresh solution prepared in 3 parts of melted·snow water. A dose of 0.1 g/kg body weight proved suitable. A dosage of 0.05 g/kg had no visible effect, while doses of 0.15 g/kg and more proved toxic (animals administered preparations of 0.2 and 0.25 g/kg dosage perished).

The efficacity of ditrazine-phosphate was tested on two groups of elaphostrongyl-infected marals (14 animals in each group). One group was given a single treatment, the other group was given a second dose after 24 hours.

FIGURE 5. Elaphostrongyls in the spinal cord tissues of a maral

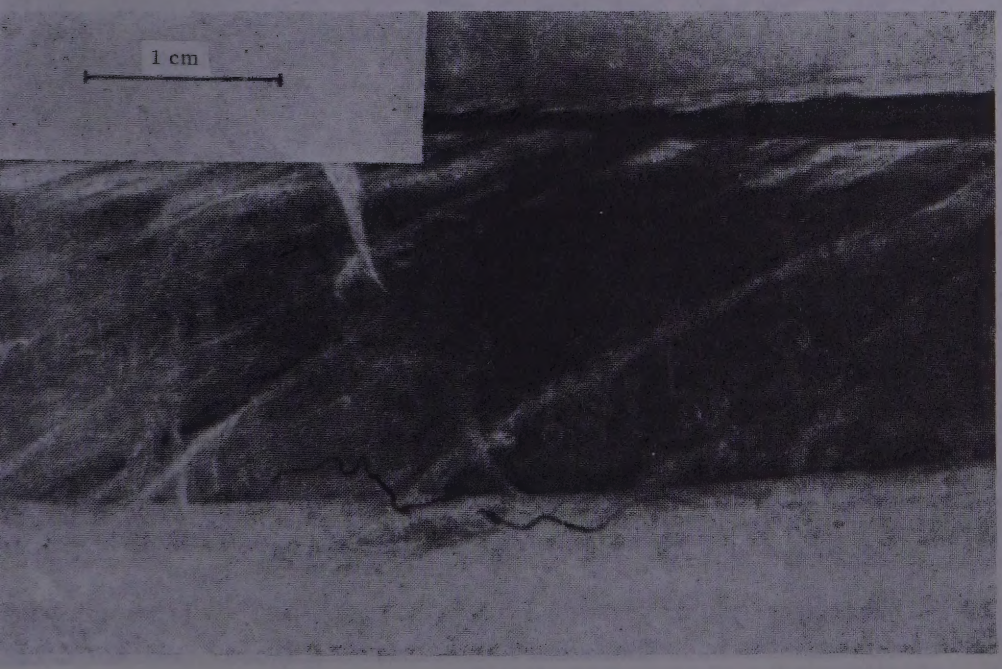

FIGURE 6. Elaphostrongyls in intercostal muscles of a maral

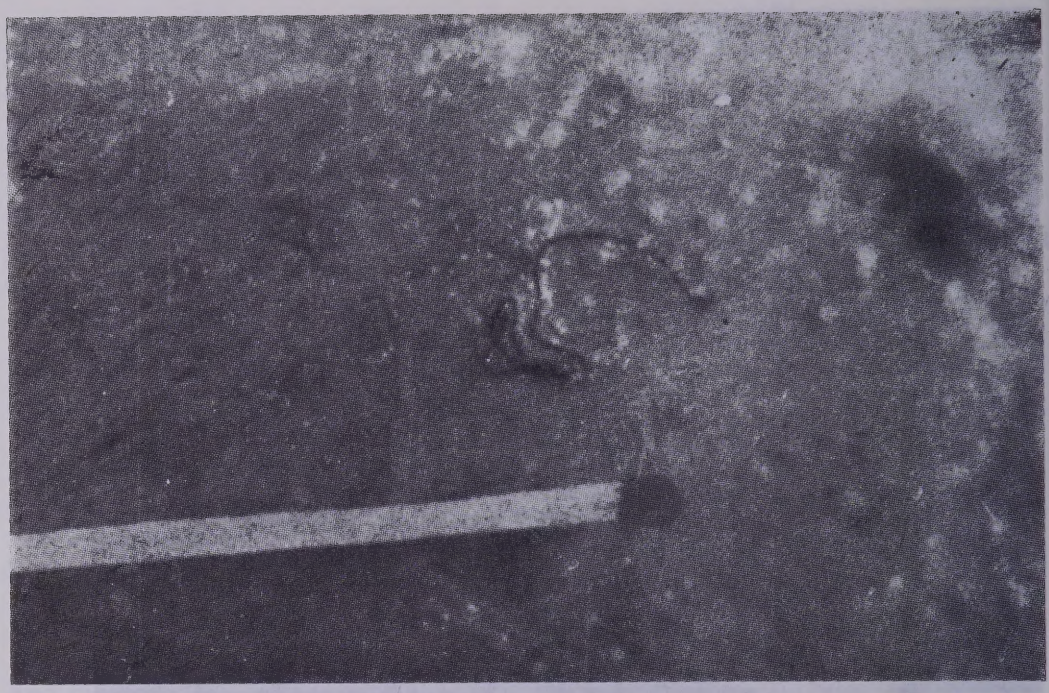

FIGURE 7. Elaphostrongyls in the peritoneum of a maral

FIGURE 8. Elaphostrongylosis-stricken maral (typical lagging behind the herd and prolonged immobility; sudden aggressiveness is possible)

FIGURE 9. Elaphostrongylosis-stricken maral (paralysis)

This experiment showed no success in destroying helminths. Coprological examinations before and after treatment showed no appreciable differences between the average numbers of larvae in the microscopic field (samples were examined on 3 consecutive days before, and 3 times from the third day after treatment). The average number of larvae in the single dose group was 40 larvae before the experiment, and 38 after the experiment, in the double dose group, 42 and 25 larvae respectively. Dissections of experimental animals (five days after the treatment) indicated that the motility of elaphostrongyls underneath the dura mater remains the same as in animals dissected before the experiment.

GURE 10. Lumbar paralysis in spotted
er (paresis of the pelvic region)

The above facts indicate that ditrazine-phosphate is ineffective against elaphostrongylosis.

However, this preparation (in dosage of 0.1 g/kg) proved highly efficacious against Dictyocaulus infestation of marals. Where before treatment, over half of experimental animals excreted active Dictyocaulus larvae and in every dissection scores and even hundreds of adult Dictyocaulus were detected, after e treatment larvae disappeared in all marals and in dissections no exually mature helminths were detected.

Phenothiazine, as a prophylactic against elaphostrongylosis, was recommended by Lyubimov in what seem to us rather large daily doses: 25.0 to 30.0 g for 12 days to adult stag, or 70.0 g for 4 days.

We tried to determine the effectiveness of this preparation in smaller doses (adult stags: 7.5 to 10.0 g; maral does: 6.0 to 7.0 g; $1\frac{1}{2}$-year-old animals: 3.0 to 4.0 g; very young maral calves: 2.0 to 3.0 g). Month-long administration of the anthelminthic mixed in silage did not result in any reduction in the number of larvae in fecal samples.

At the present time no remedy can be recommended as a therapeutic or prophylactic in elaphostrongylosis. For the present, the most effective measure seems to be to raise resistance to elaphostrongyls. The first condition for this is improved feeding and maintenance of the animals, the second is drainage of the park and pasturage of young animals on dry pastures, and the third condition is the application of sanitation measures to protect the maral herd from Dictyocaulus infection and other infectious diseases.

Conclusions

1. On deer-breeding farms of East Kazakhstan elaphostrongylosis is widespread and causes great losses.
2. Young marals up to the age of $1\frac{1}{2}$ years are most susceptible to elaphostrongylosis.
3. Elaphostrongylosis incidence shows a marked seasonal variability in clinical form; it is as a rule prevalent in winter.
4. Not infrequently, cases of elaphostrongylosis are complicated by Setaria infection of the brain as well as Dictyocaulus and Trichuris.
5. Ditrazine-phosphate, administered subcutaneously, proved ineffective in elaphostrongylosis, but very efficacious against Dictyocaulus infection.
6. Until effective anthelminthics for elaphostrongylosis are discovered, measures for increased organism resistance and sanitation of the parks must be applied.

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